



PATENT APPLICATION

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Waveguide

SPECIFICATION

Statement of Government Interest

The invention was made with Government support under
contract No. F04701-93-C-0094 by the Department of the Air
Force. The Government has certain rights in the invention.

Field of the Invention

The invention relates to the field of antenna systems used
in satellite communications where orthogonal polarizations are
employed to increase system capacity.

Background of the Invention

The demands for satellite communication capacity have resulted in the implementation of several different techniques. One technique is to extend satellite capacity using orthogonal polarization states to send two independent signals to the same coverage region thereby doubling the information that can be delivered to that region. This technique is referred to as polarization reuse. The success of this technique depends in part on the ability to maintain the separation of the two signals to avoid mutual interference that degrades communication performance. The required signal separation in turn imposes requirements on the polarization purity of the signals.

Polarization reuse is very commonly used on commercial satellites operating at the C band (4-6 GHz) and Ku band (11-14 GHz) frequencies. The required separation between signals used in these systems depends on the power differences in the signal levels and the susceptibility of the reception to co-channel interference. A typical requirement for the polarization purity needed for signal separation is to limit the reception of the undesired signal to a level that is 27 dB lower, that is, 1/500 of the power, than the desired signal component. The degree of polarization purity needed to satisfy this requirement is significantly more stringent than the polarization purity required to insure minimal signal loss caused by polarization mismatch.

1
2 Different satellite systems, however, are not consistent
3 in the polarization states used. Some systems use orthogonal
4 linear polarization states while other systems use orthogonal
5 circular polarization states. Within a given satellite system,
6 antenna systems for a single polarization state have been
7 developed. However, if antenna systems are developed for use
8 with several different satellite systems, the antenna system
9 requires the capability to select the polarization state
10 depending on the satellite system being used. Clearly, antenna
11 systems capable of operating with different satellite systems
12 afford advantages in flexibility and potential cost
13 effectiveness. However, such antenna designs have to be fully
14 compatible with the requirements for each satellite system. In
15 view of the various polarization signaling methods, antenna
16 systems designed for inter-program compatibility must be
17 capable of processing dual polarization signals with either
18 linear or circular polarization states and must meet system
19 requirements for polarization purity.

20
21 The design requirements to achieve the requisite
22 polarization purity must address the antenna, its feed system,
23 and the ports for each polarization. These design requirements
24 must be maintained over the entire bandwidth spanned by the
25 satellite systems. The antenna, for example, must be designed
26 with a high degree of symmetry so that cross polarized
27 components are not generated that would degrade polarization
28 purity. Similarly, the feed system must be designed to produce

1 rotationally symmetric illumination of the antenna system and
2 attention must be paid to the excitation of higher order modes
3 that produce cross polarized components that degrade
4 polarization purity. The terminals of the feed system must be
5 constructed with precision to avoid polarization coupling, and
6 any combining circuitry used to transform polarization states
7 must satisfy stringent matching requirements to avoid the
8 generation of cross polarized components that degrade
9 polarization purity. The satisfaction of the overall system
10 requirements for polarization purity is limited by the
11 aggregate of the imperfections in the antenna, feed system,
12 terminals and transforming circuitry.

13
14 One fundamental limitation in the development of designs
15 that permit selection of the polarization state results from
16 the inherent imperfections when hybrid combining circuitry is
17 used to transform polarization states. The conventional
18 approach to this problem is to combine one of the polarization
19 states with hybrid circuitry to obtain the other polarization
20 state. The limitation of this approach lies with the inherent
21 imperfections of the hybrid. Quadrature hybrids needed to
22 convert the linearly polarized state to the circular polarized
23 state can maintain a ninety degree phase shift but the
24 amplitude response is unequal over the bandwidth. This
25 amplitude imbalance results in coupling between the two
26 polarization states resulting in co-channel interference. When
27 linearly polarized components are transformed to circularly
28 polarized components, for example, the circular components are

1 obtained from the addition of equal levels of each linearly
2 polarized component with a ninety degree phase shift between
3 the components. Such combining is typically implemented using
4 a quadrature hybrid. Practical hybrids provide the appropriate
5 ninety degree phase shift but exhibit the problem of an
6 imbalance when combining the amplitudes that then varies over
7 the required bandwidth. This amplitude combining imbalance is
8 a limiting factor in achieving the polarization isolation
9 needed to maintain signal separation. A similar limitation
10 exists with one hundred and eighty degree hybrids used to
11 combine circularly polarized components to obtain linearly
12 polarized components. One problem with one hundred and eighty
13 degree hybrids is the resulting phase imbalance. A second
14 problem is the insertion loss inherent when using combining
15 circuitry results. Such insertion loss degrades system
16 sensitivity. The insertion loss reduces transmitted power
17 delivered to the antenna and also limits the power handling
18 because the thermal energy resulting from the insertion loss
19 must be dissipated. The insertion loss in receiving antennas
20 not only reduces the received signal strength but also
21 increases the total system temperature, a factor that is
22 extremely important when modern low noise receivers are used.

23
24 A means of switching is also required to select between
25 the polarization states. Three distinct switch technologies
26 exist. Diode switch devices can switch very rapidly but are
27 relatively lossy and limited in their power handling
28 capability. Ferrite switching technology has somewhat less

1 loss, slower switching time, and greater power handling
2 capability and very low loss, but with disadvantageous slow
3 switching times. The low loss and power handling capabilities
4 are desired in this polarization reuse applications and rapid
5 switching may not present a problem. Thus, waveguide switch
6 technology is preferred in this polarization reuse application
7 having low loss and high power handling capabilities, but with
8 slow switching times. Conventional waveguide switch has a
9 single dominant waveguide mode. A dominant waveguide mode may
10 be TE₀₁ or TE₁₀ for square waveguides and orthogonally disposed
11 TE₁₁ for circular waveguides. Tapers and frequency selective
12 surfaces have long been used for frequency isolation. The most
13 familiar waveguide switch uses rotating waveguide bends to
14 route the signals between four ports. The conventional
15 waveguide switch has two selectable position settings for
16 aligning two curved waveguide section bends symmetrical about a
17 rotating axis. The curved selectable waveguide section does
18 not use reflecting surfaces, and is limited to rectangular
19 cross section waveguide sections incapable of communicating
20 orthogonally polarized signals. This dual position arrangement
21 is analogous to a double-pole double throw switch. This
22 configuration is commonly referred to as a baseball switch,
23 because the waveguide bends resemble the stitching on a
24 baseball. However, this switch technology is not capable of
25 switching orthogonally polarized signals because the bends
26 inherently result in coupling between the linear and circular
27 polarized signals. These and other disadvantages are solved or
28 reduced using this invention.

Summary of the Invention

An object of the invention is the capability to receive and/or transmit dual orthogonally polarized signals with selection between linear and circular states.

Another object of the invention is to achieve a high degree of polarization purity over a wide bandwidth to avoid co-channel interference of one signal to another.

Yet another object of the invention is to achieve a low loss design to increase system efficiency in antenna systems.

A further object of the present invention is to provide the means of transmitting and/or receiving two orthogonally polarized antenna signals with a high degree of polarization purity and with low loss and the capability to select either linearly or circularly polarized polarization states.

Yet a further object of the present invention is to provide the capability for a dual polarized, selectable polarization state waveguide capable of operation for multiple frequency bands.

The present invention is directed towards a waveguide switch having a plurality of switch positions for communicating a signal between at least one input port and a respective plurality of output ports through a respective plurality of

1 dissimilar waveguide sections. In the preferred form, the
2 waveguide switch has two output ports respectively connected to
3 the input port through a straight waveguide section and a bent
4 waveguide section. The waveguide switch is preferably used to
5 receive and/or transmit dual polarized signals through an
6 antenna feed input port between a linear output port using the
7 bent waveguide section coupled to a linear polarization state
8 sensitive probe and a circular output port coupled to a
9 circular polarized probe using the straight waveguide section
10 providing the capability to select either linearly or
11 circularly polarized polarization state signal transmitted
12 through the antenna feed port. This present invention provides
13 a high level of polarization purity needed to separate two
14 independent signals by polarization. The present invention is
15 directed to selectable waveguides having selectable waveguide
16 sections to perform the polarization state selection, and the
17 loss incurred by these sections is much less than the losses in
18 hybrid combining circuitry used in the conventional
19 polarization state transformations. The waveguide sections can
20 be sized, cascaded and coupled to frequency sensitive tapers
21 and couplers for both polarization state selection and
22 frequency selection of signals in applications where multiple
23 frequency or multiple polarization state operation is required,
24 for example, in simultaneous C band and Ku band operation.

25
26 The preferred selectable waveguide has two positions for
27 respectively selecting one of two waveguide sections within the
28 selectable waveguide. The selectable waveguide is capable of

1 propagating the two independent orthogonal polarized channels.
2 A waveguide is connected to an antenna feed capable of
3 propagating two independent orthogonally polarized
4 communication channels. A selector switch, knob, or other
5 mechanical means on the waveguide is used to select one of the
6 two waveguide sections to thereby select one of the two
7 independent orthogonally polarized communication channels.
8 Output ports of the selectable waveguide are used for
9 separating the respective polarization states of the channels
10 using respective polarization sensitive probes. The waveguide
11 switch is thus used to route the transmitting or receive
12 channel signals into either the circular polarized output port
13 realized by an orthomode transducer capable of high
14 polarization purity over wide bandwidths or to the linear
15 polarized output port realized by an orthogonal linear
16 polarized probe in the waveguide capable of high polarization
17 purity over wide bandwidths.

18
19 Preferably, the selector switch is used to transfer either
20 linear or circular polarization signal components to respective
21 ports. Like the conventional waveguide switch, the selection
22 is preferably accomplished by mechanical rotation. Unlike
23 conventional switches, however, the improved selectable
24 waveguide has dissimilar waveguide sections that can
25 respectively operate in two dominant modes. One switch setting
26 consists of a straight waveguide section so that higher order
27 modes and mode coupling does not occur. The second switch
28 setting changes the direction of propagation by ninety degrees

1 using a waveguide miter bend to avoid higher order mode
2 generation. The axis of rotation is offset to permit the
3 rotation of the switch and the port alignment. The improved
4 selectable waveguide switch of the present invention is
5 effectively a single-pole double-throw waveguide switch using
6 three ports.

7
8 These selectable waveguide switches can be frequency sized
9 and cascaded for multiple frequency applications. Such
10 cascading can be readily performed when the switch has the
11 straight waveguide section. When the switch is placed in the
12 position of bent section containing a miter bend, the
13 conducting miter is replaced by a frequency selective surface
14 to allow passage of the higher frequency signals to subsequent
15 selector waveguide switches. Frequency sensitive couplers and
16 tapers can be coupled to the switches to various operational
17 configurations for selecting the signal of desired frequency
18 and polarization. In addition to the ability to maintain
19 polarization purity, the waveguide sections of the selector
20 switch have little loss in comparison to hybrid network losses
21 in the conventional approach. These and other advantages will
22 become more apparent from the following detailed description of
23 the preferred embodiment.

Brief Description of the Drawings

Figure 1 is a drawing of a selectable waveguide switch shown in the straight position.

Figure 2 is a drawing of the selectable waveguide switch shown in the bent position.

Figure 3a is a drawing of a modified selectable waveguide having a modified bent waveguide section.

Figure 3b is a drawing of the modified selectable waveguide in the straight position with an attached coupler for multiple frequency operation.

Figure 4 is a drawing illustrating a cascade arrangement of selectable waveguides for multiple frequency operation.

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Detailed Description of the Preferred Embodiment

An embodiment of the invention is described with reference to the figures using reference designations as shown in the figures. Referring to both Figures 1 and 2, a selectable waveguide can be positioned into one of two positions, a straight waveguide position shown in Figure 1 and a bent waveguide position shown in Figure 2. An antenna feed port 10 communicates a feed signal 12 to and from an antenna feed 13. In the straight position of Figure 1, the antenna feed port 10 communicates the feed signal 12 through a straight waveguide section 14 to a circular port 16 communicating a circular port signal 18. The waveguide sections 14 and 20 are physically sized to transmit and receive signals within desired frequencies bands. The circular port signal 16 may be either a linearly polarized signal or a circularly polarized signal or may comprise a plurality of differing polarized signals. The circular port 16 is coupled a circular port probe 19 for communicating the circular port signals 18 to and from the antenna feed port 10. The feed signal 12 is either a linear polarized signal or a circular polarized signal, or may be a composite signal having a plurality of differing polarized signals having respective polarized states. In the bent position of Figure 2, the selectable waveguide communicates the feed signal 12 through a bent waveguide section 20 to a linear port 22 communicating a linear port signal 24 that may be either a linearly polarized signal or a circular polarized signal and that may comprise a plurality of differing polarized

1 signals. The linear port 22 is coupled to a linear port probe
2 25 for communicating the linear port signal 24 to and from the
3 antenna feed port 10.

4
5 The bent waveguide section 20 has a reflecting surface 26
6 for reflecting the feed signal 12 and linear port signal 24
7 communicated through the bent waveguide section 20. The
8 direction of the signal path through the bent waveguide section
9 20 is reflected by ninety degrees using the reflecting surface
10 26 in the path of the bent waveguide section 20 to communicate
11 linear polarized signals between the linear port 22 and the
12 antenna feed port 10. The reflecting surface 26 is for
13 reflecting signals 24 and 12 communicated through the bent
14 waveguide section 26. This reflection is achieved by a miter
15 bend to avoid mode conversion and coupling between the
16 polarized component signals of the signals 24 and 12 that would
17 reduce the separation between component signals.

18
19 From Figures 1 and 2, it should be apparent that the bent
20 waveguide section 20 connects the feed port 10 to the port 22
21 when in a first position, and is therefore dissimilar to in
22 shape to the straight waveguide section ¹⁴(20). Also, the straight
23 waveguide section ¹⁴(20) connects the feed port 10 to the port 16
24 when in a second position, and is also therefore dissimilar in
25 shape to the bent waveguide section 20. That is, the two
26 waveguide sections 14 and 20 must be dissimilar in shape for
27 connecting the feed port 10 to respective output ports 16 and
28 22. Additionally, while the preferred form has only two

1 sections 14 and 20, additional sections could be added, so that
2 there is at least a plurality of the dissimilar waveguide with
3 respective sections and output ports.

4
5 The port 10 is designated generally as an input port, and,
6 the ports 22 and 16 are designated generally as output ports,
P7 but, ports 16 and 22 may transceive ^{respective} signals 24 and 18 to and
8 from the port 10 as the feed signal 12. The signal 12 is
9 generally designated as an input signal having a plurality of
10 component signals, such as signals 24 and 18, having differing
11 orthogonal polarization states, such as linear or circular
12 polarization states, left hand circular or right hand circular
13 polarization states, and linear horizontal or linear vertical
14 polarization states. The signal separation and isolation by
15 desired polarization states are realized by polarization
16 sensitive probes 19 and 25 and waveguide switch selection at
17 the respective straight and bent switch positions.

18
19 To change positions from a bent waveguide position to and
20 from a straight waveguide position, the selectable waveguide
21 has a rotating selector knob 28 or other mechanical means for
22 rotating a rotating element 30 supporting the bent waveguide
23 section 20 and straight waveguide section 14 on a stationary
24 housing 32. The selectable waveguide preferably uses the
25 rotating element 30 in the stationary housing 32 to change
26 positions for respectively communicating signals 18 or 24. As
27 preferably designated, the selectable waveguide uses the bent
28 waveguide 20 to communicate linearly polarized signals 24 and

1 uses the straight waveguide 14 to preferably communicate
2 circularly polarized signals 18. The bent waveguide section 20
3 and the straight waveguide section 14 can have either a square
4 or circular cross section and sized for the frequencies of
5 interest. The manually actuated rotating knob 28 is rotated to
6 connect either the bent waveguide 20 or the straight waveguide
7 14 between the antenna feed port 10 and either of the linear
8 port 22 or the circular port 16, respectively. Hence, the bent
9 waveguide section 20 preferably communicates a linearly
10 polarized signal 24 as feed signal 12 between the linearly
11 polarized port 22 and the antenna feed port 10, and, the
12 straight waveguide section 14 preferably communicates circular
13 polarized signals ¹⁸(12) as feed signal 12 between the circularly
14 polarized port 16 and the antenna feed port ¹⁰(12). Hence, the
15 rotating knob 28 only has two positions, the first position
16 connecting the linear port 22 to the antenna feed port 10 for
17 linearly polarized signal communication as shown in Figure 2,
18 and the second position connecting the circular port 16 to the
19 antenna feed port 10 for circularly polarized signal
20 communication as shown in Figure 1.

21
22 The polarization sensitive probes 19 and 25 are
23 preferably used to ^{respectively}separate by polarization states the two
24 orthogonal polarized signals 18 and 24. The linear port 22 may
25 communicate two independent signals separated by orthogonal
26 polarization states, such as, linear horizontal and linear
27 vertical polarization states. Likewise, the circular port ¹⁶(22)
28 may communicate two independent signals separated by orthogonal

1 polarization states, such as, left hand and right hand circular
2 polarization signals. Each of the probes 19 or 25 are
3 preferably responsive to a predetermined polarization state and
4 as such are used to isolate and separate two independent
5 orthogonally polarized component signals.

6
7 By rotating the rotating element for waveguide section
8 alignment, the probes 19 and 25 are thereby rotated into a
9 position for receiving or transmitting one of the plurality of
10 differing polarized signals, thereby perfecting a polarization
11 state selection. The waveguide cross sections^{of} 14 and 20
12 remains unaltered from the antenna feed port 10 to either of
13 the linear port 22 and the circular port 16. The cross section
14 areas of the waveguide sections 14 and 20 remain fixed within
15 the selectable waveguide. Because the waveguide cross section
16 remains unchanged, no mechanism exists for polarization
17 modifications from antenna feed port 10 through the waveguide
18 sections 14 and 20 to the ^{respective} ports 22 and 16. Consequently, the
19 waveguide does not degrade polarization isolation. The
20 waveguide cross sections 14 and 20 may be square and in this
21 case the signals are propagated on TE01 and TE10 waveguide
22 modes. The waveguide cross section can also be circular and
23 the signals 18 and 24 are propagated on orthogonal TE11
24 waveguide modes. Hence, the waveguide cross section of the
25 sections 14 and 20 is preferably preserved throughout the
26 rotating member 30.

1 The waveguide section selection, and hence polarization
2 state selection, by rotating the knob 28, may be by
3 conventional mechanical means to route the feed signals 12 to
4 one of port 22 and 16 to thereby place a respective
5 polarization sensitive probe (19) or (25) in the path of feed
6 signal 12. Like conventional waveguide baseball switches, the
7 rotation can be manually performed or accomplished by using a
8 motor drive that can be remotely controlled. However, the
9 waveguide section selection knob 28 has the improved features
10 of offering polarization state selection using dissimilar
11 waveguide sections 14 and 20 and using respective dissimilar
12 polarization state sensitive probes 19 and 25. The rotating
13 knob 28 is used to both select one waveguide section 14 or 20,
14 and to simultaneously select the one of the two respective
15 probes 19 and 25 to perfect polarization state selection. The
16 first switch selection position selects the straight waveguide
17 section 14 and probe 19 to connect the antenna feed port 10 to
18 the circular port 16, and to select the polarization sensitive
19 probe 19 communicating signal (24) of one polarization state as
20 shown in Figure 1. The second switch selection position is
21 obtained by rotating the knob one hundred and eighty degrees to
22 select the bent waveguide section 20 of the selectable
23 waveguide to connect the antenna feed port 10 to the linear
24 port 22, and to select the probe (25) communicating signal (18)²⁴
25 having a differing polarization state as shown in Figure 2.
26 Hence, the knob 28 is in effect a polarization state selection
27 knob 28 to select one of a plurality of orthogonally polarized
28

1 signals without coupling energy between the signals that would
2 otherwise degrade the signal separation.

3
4 Communication devices, such as probes 19 and 25,
5 connected at the circular port 16 and the linear port 22, are
6 designed to separate the component signals by their
7 polarization states. A means for separating polarized signals
8 10 is to place probes in a waveguide section located ninety
9 degrees apart in adjacent walls of the waveguides. Similarly,
10 the ports 22 and 16 would separate polarized signals typically
11 by an orthomode probe. These probes for separating signals by
12 polarization are well known and capable of operation over wide
13 bandwidths.

14
15
16 The losses in dual polarized signal communication through
17 the selectable waveguide result from the losses within the
18 waveguide sections 14 and 22 which losses are very small. The
19 losses in the waveguide sections 14 and 20 are less than the
20 insertion losses associated with conventional hybrid networks.
21 Thus, signal reception and transmission for the present
22 invention are more efficient. The waveguide sections 14 and 20
23 are preferably used to select one of the two orthogonally
24 polarized signals by virtue of the polarization sensitivity of
25 the probes 19 and 25, but can also be used to select signals 18
26 and 24 of differing frequencies.

1 Referring to Figures 3a, a modified selectable waveguide
2 39 may be used for both polarization state and frequency
3 selection of the feed signal 12 communicated to the antenna
4 feed 13. The input port 10 receives from the antenna 13 the
5 polarized signal 12 and communicates the signal 12 through
6 either of the waveguide sections 14 and 20 depending on which
7 of the sections 14 or 20 is in alignment with the input port
8 10. The modified selectable waveguide section 40 can be used in
9 applications where multiple frequency operation is required.
10 The waveguide 39 is initially sized to communicate signals
11 within desired frequency bands. The modified selectable
12 waveguide 39 includes a modified bent waveguide section 40
13 having an extended straight portion 42 and a frequency
14 selective reflective surface 44. The extended portion 42 is
15 aligned to the port 16 when the bent waveguide section 40 is
16 aligned to port 22 when the modified selectable waveguide 39 is
17 switched to the bent position. The frequency selective
18 reflective surface 44 is used to reflect signals 24 of one
19 frequency, such as low frequency signals, to the port 22, and
20 to pass signals (18) of another frequency, such as high frequency
21 signals, to the port 16. The probes 19 and 25 can then be used
22 to select signals of differing polarization states, and by
23 virtue of the frequency sensitive reflective surface 44,
24 concurrently select signals of differing frequencies.

25
26 Referring to Figure 3b, the modified selectable waveguide
27 39 is attached to a coupler 46 having a left hand port 48
28 communicating left hand port signal 47 to a left hand probe 49,

1 and, having a right hand port 50 communicating right hand port
2 signals 51 to a right hand probe 53. ^{a₂} As such, the probes 53
3 and 49 are used to isolate orthogonally polarized signals, such
4 as right hand circular and left hand circular polarized
5 signals. It should be apparent that the coupler 46 functions
6 as a splitter providing two outputs, and that the coupler 46
7 and probes 49 and 53 could, as well, be attached to port 22 for
8 respectively communicating horizontal linear and vertical
9 linear orthogonally polarized signals 24. The coupler 46 has a
10 taper port 52 for attenuating low frequency component signals
11 and passing high frequency component signals 54 to the probe
12 19. The input port 10 receives from the antenna 13 the
13 polarized signal 12 and communicates the signal 12 through
14 either of the waveguide sections 14 and 40 depending on which
15 of the sections 14 or 40 is in alignment with the input port
16 10. The waveguide section 40 has an extended straight portion
17 42 and a frequency selective reflective surface 44 that is a
18 forty five degree reflective surface used to reflect signals 24
19 of one frequency, such as low frequency signals, to the port 22
20 and to pass signals 18 of another frequency, such as high
21 frequency signals, to port 16. The probes 19 and 25 can then be
22 used to select signals of differing polarization states and by
23 virtue of the frequency sensitive reflective surface 44,
24 concurrently select signals of differing frequencies. Hence,
25 the modified selectable waveguide 39 can be modified to include
26 means that provide frequency selection while the probes 25 and
27 19 can be used to select desired polarization states to isolate
28 signals of interest. It should now be equally apparent, that

1 the selectable waveguide of Figures 1 and 2, and or the
2 modified selectable waveguide 39 of Figures 3a and 3b, can be
3 used in combination with various probes, couplers and tapers to
4 isolate signal of desired polarization states and frequencies.
5 Further still, the selectable waveguide of Figures 1 and 2, and
6 or the modified selectable waveguide 39 of Figures 3a and 3b,
7 can be cascaded and used in combination with various probes,
8 couplers and tapers to isolate many different signals of
9 respective desired polarization states and frequencies.

10
11 Referring to Figure 4, two modified selectable waveguides,
12 a front end waveguide 39a and a back end waveguide 39b, are
13 cascaded for multiple frequency and multiple polarization state
14 communication applications. Frequency selection and
15 polarization state selection are enabled by the cascaded
16 arrangement in combination with various probes, couplers and
17 tapers. The two waveguides 39a and 39b are both shown in the
18 straight position, but either or both may be rotated to the
19 bent position, thereby providing a four position cascaded
20 arrangement providing a straight-straight position, a
21 straight-bent position, a bent-straight position and a bent-
22 bent position.

23
24 In the straight position, the waveguide dimension is
25 chosen to permit propagation of all system frequencies. The
26 straight position is preferably used for communicating
27 circularly polarized signals at the lower frequencies. All of
28 the signals propagate unmodified through the straight waveguide

1 sections 14a and 14b. At the output circular port 16a of the
2 modified selectable waveguide 39a, the coupler 46a is used to
3 separate the lowest frequency signals into ports 48a and 50a.
4 The port 48a can be used for left hand polarized signals, and
5 the port 50a can be used for selecting right hand polarized
6 signals in the lowest frequency band. The coupler 46a is
7 transparent to the higher frequencies. The design of such
8 couplers is well known and commonly used. The waveguide taper
9 52a follows the coupler 46a so that the waveguide size is
10 reduced permitting propagation of signals of all frequencies
11 except the lowest frequency signals. The second modified
12 selectable waveguide 39b has smaller dimensions and follows the
13 taper port 52a. The selectable waveguide 39a is transparent to
14 frequency bands above the lowest frequencies. The coupling of
15 the lower frequency band to ports 22a and 22b is enabled in the
16 bent positions. The miter bends have frequency selection
17 surfaces 44a and 44b in place of a conducting surface 26 used
18 by the single frequency selectable waveguide switch design.
19 These frequency selective miter surfaces 44a and 44b reflect
20 the lowest frequency signals 24a and 24b into the linearly
21 polarized ports 22a and 22b for connection to respective probes
22 ^{25a and 25b} (25ab). The frequency selective miter surfaces 44a and 44b are
23 transparent to higher frequencies so that the higher frequency
24 signals 54a can be communicated through the cascaded
25 arrangement at the higher frequencies.
26

27 Each of the modified selectable waveguides 39a and 39b,
28 respectively includes ports 16a and 16b, 22a and 22b, 48a and

1 48b, and 50a and 50b, tapers 52a and 52b, straight waveguide
2 sections 14a and 14b, and bent waveguide sections 40a and 40b.
3 Waveguide 39a has the feed port 10a receiving the feed signal
4 12 and provides the output signal 54a that is fed into the feed
5 port 10b of waveguide 39b to provide the output signal 54b to
6 probe 19. Probes 25a and 25b respectively communicating
7 signals 24a and 24b, probes 49a and 49b respectively
8 communicating signals 47a and 47b, probes ^{53a and 53b} (53ab) respectively
9 communicating signals 51a and 51b, and probe 19 communicating
10 signal 54b, all of which can be used for selecting signals of
11 differing frequencies and polarization states. The input port
12 10a receives from the antenna 13 the polarized signal 12 and
13 communicates the signal 12 through either of the waveguide
14 sections 14a and 40a depending on which of the sections 14a or
15 40a of waveguide 39a is in alignment with the input port 10a.
16 The bent section 40a includes a forty five degree reflective
17 surface 44a that is used to reflect signals 24a of one
18 frequency, such as low frequency signals, to the port 22a and
19 to pass signals 54a of another frequency, such as high
20 frequency signals, through the port 16a, through coupler ^{46a} (36a)
21 and through to port 52a as communication signals 54a. The input
22 port 10b of waveguide 39b receives signals 54a from the
23 waveguide 39a and communicates the signal 54a through either of
24 the waveguide sections 14b and 40b depending on which of the
25 sections 14b or 40b of waveguide 39b is in alignment with the
26 input port 10b. The bent section 40b includes a forty five
27 degree reflective surface 44b that is used to reflect signals
28 24b of one frequency, such as low frequency signals, to the

port 22b and to pass signals 54b of another frequency, such as high frequency signals, through port 16b, through coupler 46b and through port 52b to the probe 19.

The cascaded arrangement places the low frequency band modified selectable waveguide 39a closest to the antenna feed port 10a and the antenna feed 13, whereas the high frequency band modified selectable waveguide 39b may be used to communicate signals in a high frequency band. In the polarized selectable waveguide 39a closest to the antenna feed 13, a modification can be made to miter bend. In single frequency designs, the miter bend 44a consists of a conducting surface 26. In the multiple frequency design, the conducting miter surface 26 is replaced by a frequency selective surface 44a capable of reflecting the lowest frequency components and passing the higher frequency components. The coupler 46a passes only low frequency signals to ports 48a and 50a. The coupler 46b passes only high frequency signals to the ports 48b and 50b. Another frequency selective surface 44b can be used to prevent mode conversion and signal loss for the higher frequency components. The frequency selective surfaces 44a and 44b and taper ports 52a and 52b can be used for low, high, higher frequency band isolation.

In the straight-straight position, the arrangement passes low frequency signals 47a and 51a, passes high frequency signals 54a, 47b and 51b, and passes higher frequency signals 54b. In the bent-straight position, the arrangement passes low

1 frequency signals 25a, passes high frequency signals 54a, 47b
2 and 50b, and passes higher frequency signals 54b. In the
3 straight-bent position, the arrangement passes low frequency
4 signals 47a and 51a, passes high frequency signals 54a, 25b,
5 47b and 51b, and passes higher frequency signals 54b. In the
6 bent-bent position, the arrangement passes low frequency
7 signals 25a, passes high frequency signals 54a and 25b, and
8 passes higher frequency signals 47b, ^{51b}(50b), and 54b. Preferably,
9 the port 22a communicates low frequency linearly polarized
10 signals 24a to probe 25a, port 48a communicates low frequency
11 left hand circularly polarized signals 47a to probe 49a, port
12 50a communicates low frequency right hand circularly polarized
13 signals 51a to probe 53a, port 52a communicates high frequency
14 signals to port 10b, port 22b communicates high frequency
15 linearly polarized signals 24b to probe 25b, port 48b
16 communicates high frequency left hand circularly polarized
17 signals 47b to probe 49b, port 50b communicates high frequency
18 right hand circularly polarized signals 51b to probe 53b, and
19 port 52b communicates higher frequency signals to probe 19.

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21 As may now be apparent, several selectable waveguides in
22 combination with various frequency sensitive couplers and
23 tapers can be coupled together and cascaded to provide a
24 plurality of polarization states and frequency selections, all
25 by means of simple rotation of the selectable waveguides.
26 Hence, the selectable waveguide can be used for multiple
27 frequency and multiple polarization selection and operation
28 using both the straight and bent positions and using frequency

1 selective tapers, coupler, and surfaces. These switches are
2 cascaded so that the polarization selection can be made at
3 desired frequencies. This cascade arrangement permits
4 independent polarization selection at each of the used
5 frequencies.

6
7 The selectable waveguide switch can be readily applied a
8 frequency selection application. However, other applications
9 exist for the selectable waveguide. Waveguide switches are
10 commonly used to connect other alternatives or redundant
11 electronics into systems. For antennas designed to operate
12 with several different satellites, the selectable switch can be
13 used advantageously with different transmitters. As an
14 example, a system may be required to provide both low and high
15 data rate communications with different satellite systems. The
16 transfer of high data rate information generally requires
17 higher transmitted power than low data rate communications, and
18 the frequency assignments within the band may differ somewhat
19 between the satellite systems. The selectable waveguide switch
20 can be used to connect two different transmitters having
21 different power capabilities to the same antenna feed. Another
22 common requirement is to be able to switch transmitters between
23 the antenna and a dummy load. The dummy load permits operating
24 the transmitters for diagnostic testing without radiating
25 through the antenna causing needless interference. The
26 selectable waveguide switch can be used advantageously in this
27 application permitting use of a single dummy load for both
28 orthogonal polarization states. Such a design can be more

1 compact than one using two dummy loads for each polarization
2 state. Those skilled in the art can make enhancements,
3 improvements, and modifications to enhance the invention and
4 extend the application of the selectable waveguide switch.
5 However, those enhancements, improvements and modifications may
6 nonetheless fall within the spirit and scope of the following
7 claims.

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